Life Table and Pest Management of Corn[1]

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Pest management has become a very important aspect of crop production in recent years. One of the problems is the evaluation of whether pest control practices are being carried out effectively and economically. The life table approach is one of the methods of analyzing such a problem. The usefulness of life tables to pest management strategies has been mentioned by various investigators (Morris and Miller, 1954; Harcourt, 1970).

This paper is concerned with the life table of sweet corn kernels. The objective of the research was to determine kernel losses caused by various factors and to obtain information on whether there were "leaks" in the pest control budget of this crop.

METHODS

The results of this study were obtained from an ⅛ acre corn planting at the experimental farm of the College of Tropical Agriculture, University of Hawaii, Waimanalo, Oahu. The sweet corn variety used was H68. No insecticide was used throughout the crop.

To determine the fate of the corn kernels, samples of ears were taken at weekly intervals from the time the tip of the ears emerged from the sheath to harvest. A total of five ears were taken at random on each sampling date and they were taken from the central parts of the field to be sure that the ears had been pollinated to the maximum extent. The ears were harvested and the total number of kernels, number of unpollinated kernels, and number of corn earworm damaged kernels were recorded.

The sampling of a cohort of kernels began with young ears in which the kernels were not yet developed. At this time they were small protuberances with the undeveloped silk attached. After the first sampling the pollinated kernels enlarged while those presumably unpollinated remained undeveloped. Thus it was possible to distinguish between pollinated and unpollinated kernels at an early stage of ear development. The damage caused by the corn earworm was easily determined because by the time the larvae reached the kernels, the larvae were half-grown or larger.

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The method of sampling for life table studies used in this study was similar to that of Morris & Miller (1954) on the spruce budworm. Data were taken on a cohort of kernels; however, the same individuals were not examined at each sampling occasion. Mortality data on the same individuals could not be taken because of the necessity of using a destructive type of sampling. Therefore, the mortality data were based on samples taken from the same population.

The format and symbols used in this paper are the same as those of Harcourt (1970). The first column, x, gives age of kernels; the second, lx, the number of living; the third dxF, the factor causing death; the fourth, dx, the number dying within a specific time interval; and the fifth, 100rx, the percentage of mortality based on initial population.

There are two ways of utilizing life tables of crops (Harcourt, 1970): (1) assessing actual mortality of plants during the growth period, and (2) assessing losses or mortality in terms of dollar value of the crop, a problem in agricultural economics. Data on both mortality and dollar value losses are presented in this paper.

Life Table Data

The life table, shown in Table 1, indicates that there were two major loss factors, lack of pollination and corn earworm damage. The pollination factor was important during the first two weeks. Loss of kernels through lack of pollination was 18.6 percent during the first week and

TABLE 1. *Life table for sweet corn kernels, variety H68, Waimanalo, Oahu, September, 1972.*

Growth period (weeks) (x)	*Number of kernels per ear (lx)*	*Mortality factor (dxF)*	*Number of kernels lost per ear (dx)*	*Percent loss (100rx)*
1	759.6	Pollination failure	141.6	8.6
2	618.0	Pollination failure	64.8	8.5
		Corn earworm	2.8	0.3
			67.6	8.8
3	550.4	Unknown	1.6	0.2
		Corn earworm	0.8	0.1
			2.4	0.3
4	548.0	Unknown	40.4	5.3
		Corn earworm	13.0	1.7
			53.4	7.0
5	494.6	Unknown	1.0	0.1
		Corn earworm	22.4	2.9
			23.4	3.0
6	471.0*	Corn earworm	32.6	4.3

*Based on 3 samples; adjustment made due to accidental harvesting operations in sampling site.

8.5 percent during the second. The unknown factors, which may include lack of pollination, amounted to 0.1 to 5.3 percent.

The mortality of the kernels caused by the corn earworm was small. It ranged from 0.1 to 4.3 percent. These losses occurred primarily towards the end of the crop. Loss by the corn earworm towards the end of the crop is understandable when we consider the behavior of the larvae. Young larvae were not found in the cob; it was the nearly mature larvae that bore into the cob (Unpublished data). The total potential number of kernels per ear at the beginning was 756.6 and the final realized number at the harvest was 471.0, which represents a loss of 37.7 percent.

ECONOMICS OF CORN EARWORM DAMAGE

The amount of kernel loss attributed to lack of pollination and to corn earworm was converted into monetary values. A total of ten ears was purchased from a supermarket at the March 1973 retail price of 35 cents per pound. The tips of the purchased corn had been cut, and the husk partially removed so that the kernels at the tip were visible. The kernels were counted and the price per kernel calculated. It was then possible to calculate the total value of an acre of corn, the value of kernels lost through lack of pollination, and those lost through corn earworm feeding. The calculations were made on per acre basis using 16,250 ears per acre (Nishida & Napompeth, 1972).

From Table 2, it is evident that amount of revenue loss due to lack of pollination was greater than that of the corn earworm damage. Out of a potential realizable income of 5,431.14 dollars, lack of pollination

TABLE 2. *Revenue losses due to two major factors causing loss of kernels.*

Growth period (weeks)	*Potential revenue per acre (dollars)*	*Hazard*	*Loss of revenue per acre (dollars)*
1	5,431.14	Pollination failure	1,010.19
2	4,418.70	Pollination failure	461.65
		Corn earworm	16.29
			477.94
3	3,935.36	Unknown	10.86
		Corn earworm	5.43
			16.29
4	3,918.20	Unknown	287.85
		Corn earworm	92.33
			380.18
5	3,536.39	Unknown	5.43
		Corn earworm	157.50
			162.93
6	2,867.15	Corn earworm	228.39

amounted to 1,471.14 dollars; corn earworm damage, 499.94 dollars; and unknown factors, 304.14 dollars. After subtracting losses due to lack of pollination, corn earworm damage and unknown factors an income of 2,867.15 dollars per acre was obtained. This amount represents approximately 53.0 percent of the potentially realizable amount of 5,431.14 dollars.

The above calculations were based on a retail price of corn. According to agricultural statistical data of 1971, the retail price of sweet corn was about three times as high as that of the wholesale. Therefore, if one wishes to know the loss at the farmer's level he should take a third of the value given in Table 2.

One of the aims of pest management is to determine whether or not insecticidal treatments are necessary and to apply treatments only when necessary. The low kernel damage caused by the corn earworm even when no insecticide was used raises questions as to whether insecticidal treatments are needed. According to recent literature the best control obtainable by insecticides was about 50 percent worm-free ears. It may be seen that with such a control the treatments actually protect the kernels only to a small extent.

Besides spraying, control by removal of the distal tips of the harvested ears prior to sending the ears to the market is a common practice in Hawaii. After harvesting the ears, the grower "dresses up" his product by cutting off the distal end removing the corn earworm, fecal matter, partially eaten kernels, and nitidulid beetles which often enter infested ears. In addition, the husks are partially removed to expose the worm-free kernels. Actually this is not a control practice in the usual sense of the word. It is a cosmetic treatment to enhance the appearance and thereby improve the marketability of the product.

This cosmetic treatment is given whether or not spray applications had been made to protect the ears because the grower wants to be sure that his product would be attractive and free of corn earworms. With chemical control in the range of 50 percent worm-free ears, the grower's product without cosmetic treatment could hardly be considered acceptable to the consumer. To enhance the appearance of the corn to a point where no clipping is needed, the grower must have almost a 100 percent control because even a few wormy ears could ruin his market.

Unfortunately, there are no known treatments that give anything close to 100 percent worm-free ears. Oatman *et al.* (1970) stated that the classification of ears as "clean ears" is too stringent and impossible to attain. Oatman & Platner (1970) and others working on the control of the corn earworm have stated that the economic threshold level of the corn earworm is low, but they did not state how low. If we are striving for cosmetic effects; i.e., marketing corn without removing the tips, then the economic threshold level should be zero infestation.

At this point we should ask ourselves this question: Are insecticidal treatments needed when the ears for the market are going to be clipped to remove the kernels injured by the corn earworm? We feel that as far as H68 is concerned insecticidal treatments are not needed. By not using insecticides, the total cost of production due to labor, materials, and equipment could be reduced. But it should be pointed out that in clipping there is a loss in kernels because it is impractical to remove only the damaged kernels. It has been estimated that to remove one worm-eaten kernel 1 to 2 good kernels are discarded depending on the configuration of the damaged portion. These discards plus labor costs represents the cost of the cosmetic treatment. However, this cosmetic treatment is much more effective and cheaper than spraying with insecticides which do not give the desired level of control. Furthermore, the amount of insecticides used on a farm is reduced.

Preliminary observations on field and seed corn indicated that insecticidal treatments for the corn earworm may not be justified. The kernel damage is too small to make treatments pay for increased kernel yield. For example, observations on the field corn, Hawaiian Yellow, showed that even though 60 percent of the ears were infested by the corn earworm, the injury per ear was less than 2 percent of the kernels.

DISCUSSION

One of the factors that often contributes to an overestimation of corn earworm damage is the presence of eggs and small larvae on the silk. Early in the development of the ears one sees many eggs and larvae on the silk and in the silk channels. Thus superficially the corn earworm appears to be able to cause a great deal of damage. Our unpublished data on the variety H68, indicate that, although the percentage of infested ears and the number of larvae in the silk channel are high, the number of larvae that reaches the cob is small. We found that only one or two late instar larvae were able to reach the cob. The actual damage to the kernel is often less than expected because (1) the larva usually fed on the tip of the cob that has no kernels, and (2) the larva remained in the kernel area of the cob only for a short period, usually not more than a week, and then left the ear to pupate.

By use of life tables it was found that kernel loss due to lack of pollination was greater than that caused by the corn earworm. This loss was high even though the ear samples were taken from the central parts of the field where the chances of being pollinated were good. It seems that factors other than failure of the pollen to reach the stigma could cause kernel loss. The low kernel damage observed in this study could be due to resistance to corn earworm attack. Therefore, the statements made in this paper may not apply to highly susceptible varieties.

Life tables could be utilized in measuring resistance of corn varieties to corn earworm attack. Further studies of corn earworm damage on other varieties and under different ecological and cultural conditions are being planned and would be carried out.

Summary

A life table was constructed for kernels of sweet corn, variety H68, to assess the importance of various factors that could cause kernel loss during the developmental period of the ears. Loss caused by lack of pollination and corn earworm damage were the major factors. The loss due to lack of pollination was 27.0 percent while that due to the corn earworm damage, 9.3 percent.

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